SHIP PRODUCTION COMMITTEE
FACILITIES AND ENVIRONMENTAL EFFECTS
SURFACE PREPARATION AND COATINGS
DESIGN/PRODUCTION INTEGRATION
HUMAN RESOURCE INNOVATION
MARINE INDUSTRY STANDARDS
WELDING
INDUSTRIAL ENGINEERING
EDUCATION AND TRAINING

June 1978
NSRP 0005

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

REAPS 5th Annual Technical Symposium Proceedings

Paper No. 11: New Developments in CNC and DNC Controller Equipment For the Shipbuilding Industry

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
JUN 1978	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
The National Shipbuilding Research Program REAPS 5th Annual Technical Symposium Proceedings Paper No. 11: New Developments in CNC and DNC Controller Equipment for the Shipbuilding Industry	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Surface Warfare Center CD Code 2230 - Design Integration Tools Building 192 Room 128 9500 MacArthur Blvd Bethesda, MD 20817-5700**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

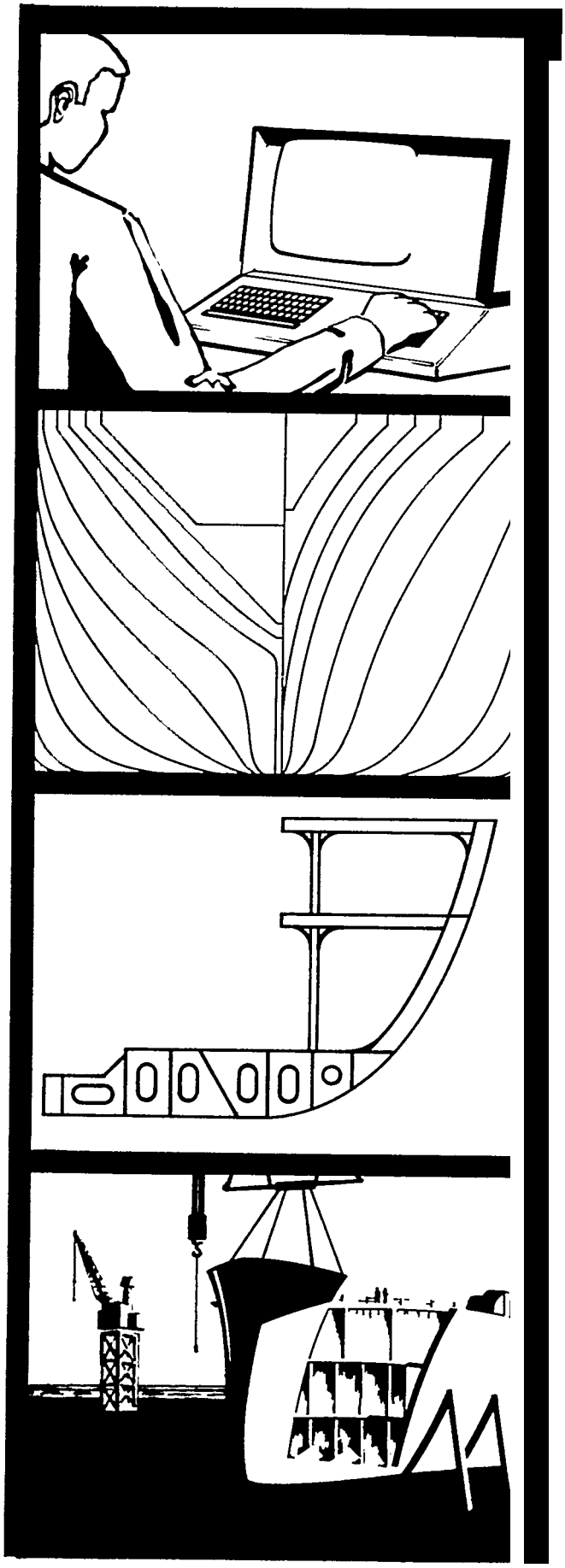
13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**14**	

NSRP-0005



R ESEARCH
AND
E NGINEERING
FOR
A UTOMATION
AND
P RODUCTIVITY
IN
S HIPBUILDING

Proceedings of the REAPS Technical Symposium

June 27-28,1978

St. Louis, Missouri

DISCLAIMER

These reports were prepared as an account of government-sponsored work. Neither the United States, nor the United States Navy, nor any person acting on behalf of the United States Navy (A) makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness or usefulness of the information contained in this report/ manual, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or (B) assumes any liabilities with respect to the use of or for damages resulting from the use of any information, apparatus, method, or process disclosed in the report. As used in the above, “Persons acting on behalf of the United States Navy” includes any employee, contractor, or subcontractor to the contractor of the United States Navy to the extent that such employee, contractor, or subcontractor to the contractor prepares, handles, or distributes, or provides access to any information pursuant to his employment or contract or subcontract to the contractor with the United States Navy. ANY POSSIBLE IMPLIED WARRANTIES OF MERCHANTABILITY AND/OR FITNESS FOR PURPOSE ARE SPECIFICALLY DISCLAIMED.

NEW DEVELOPMENTS IN CNC AND DNC CONTROLLER EQUIPMENT FOR THE SHIPBUILDING INDUSTRY

Joseph W. Belanger
Kongsberg Systems Incorporated
Bedford, Massachusetts

Mr. Belanger is a System Consultant currently responsible for designs of CNC and DNC systems. He has 15 years experience as a designer of industrial equipment and systems and has been an owner of a systems design firm.

Mr. Belanger holds a degree in electrical engineering from Worcester Polytechnical Institute, Massachusetts.

New Developments in CNC and DNC Controller Equipment for the Shipbuilding Industry

I Introduction

My talk today is based upon a development activity that I have been involved with for the last 4 years at KSI.

The ultimate goal of this development program was to produce controller equipment that would function in a DNC network and allow the end user to begin to achieve an "INTEGRATED MANUFACTURING APPROACH" to the flame cutting process.

Before I continue any further, I feel I must define some terms in order for all of us to have a common understanding of the concepts that will be introduced.

Currently, those of you who are involved with flame cutting in your yard are probably operating with either optical template or NC (Numeric Control) flame cutting equipment, In the case of the NC equipment, the controllers for this equipment are either NC "hard wired" units or CNC (Computer Numeric Control) "soft wired" units. The difference between “hard wired” and “soft wired” being the CNC controller has a general purpose digital computer as its central component, and thus, is programmed by “software” within it as opposed to being a series of fixed functions in “hard wired” controller.

Chances are, these NC or CNC controllers function entirely from paper tape. - The paper tape represents a single part or a “nested” series of parts arranged so that an entire plate can be utilized during-a single burning machine set-up.

The actual parts represented in the paper tape were probably-generated via some CAD (Computer Aided Design) function either operating in your own yard or some remote CAD service center accessed by a computer terminal connected to the telephone system.

It should be noted at this point that generally speaking, all of these functions operate independently of each other. Coordination is left to the individuals involved. The actual part program data is committed to a physical paper tape that must be-manually coordinated, again by the individuals involved. On the other end of the cutting process, that is the actual cutting operation, all operating information about that particular cutting process must be derived by manual reports, again, written by the individuals involved.

The development effort at KSI set out to integrate as many of these individual functions into a common computer based DNC (Direct Numeric Control) network. The ultimate goal of the DNC network is to provide paths for an automatic flow of information between CAD (Computer Aided Design) functions, DNC (Direct Numeric Control), and CAM (Computer Aided Manufacturing) functions. Once the DNC network is installed and becomes operational, the end user can

then begin to approach “INTEGRATED MANUFACTURING” on a practical basis.

II Network Component Design Criteria

On terms of designing controller equipment and computer systems to make up this kind of a DNC network, it was felt that all of the designs should meet the following general criteria:

(1) The network should be able to incorporate as many nodes or work stations as possible. The more individual work stations tied to the network, the higher the level of INTEGRATED MANUFACTURING achieved.

(2) The end user should not be forced to replace his existing equipment prematurely in order to achieve the DNC network. The practical feeling being that very few companies can or would commit to wholesale replacement of their existing controllers and/or burning machines and thus limit DNC network to very slow growth.

(3) All network components should be built around existing mass produced domestic mini-computers in order to achieve the highest level of integrated circuit “state of the art” at the lowest cost, provide a completely modular system expansion capability, and reduce maintenance to a minimum of complexity.

III The Network Components

(1) Burning, Machine Controller Component

The first network component designed and built was a new CNC controller. This controller was built around the Digital

Equipment Corporation PDP 8-A mini-computer. It contains all of the necessary generally accepted standard burning machine control features found on any modern CNC controller. From an operators point of view it concentrated the entire control function-to a single operators panel generally mounted on the beam of the burning machine. The actual computer in the controller is generally located up to 3000 feet away from the burning machine and is connected to the burning machine via two small cables. This concept has proven itself in actual installations involving both oxy-fuel and plasma burning, and as a general purpose 2-1/2 axis controller it is equivalent to any modern stand-alone conventional controller employing paper tape as an input medium.

This, however, is where the similarity ends. The controller is actually a network “node” as well as a controller. It has the ability to communicate in both directions with a remote DNC computer while it is also directing the burning process. An operator can, via the control panel, call for a specific . part located in some centralized parts library attached to the DNC computer. This same DNC computer can direct the operator to burn specific parts in accordance with some master schedule. When the actual burning machine begins the burning of the part, the controller monitors the various functions such as torch relay on, speed setting, etc., and automatically transmits them to the DNC computer. The DNC computer in turn, logs the event and stores it for later processing. The controller thus

becomes an input/output device to a DNC network receiving and transrmitting control information. This capability is one of the basic steps necessary in achieving INTEGRATED MANUFACTURING.

In order to satisfy the design criteria of not forcing the end user to replace his existing equipment prematurely in order to achieve the DNC network, the controller has been designed in several forms.

(1) NEW CONTROLLER, NEW BURNING MACHINE; in this case the controller is a straight forward addition to the burning machine and generally is installed by the manufacturer of the burning machine. (2) NEW CONTROLLER, OLD NC BURNING MACHINE; in this instance the controller is retrofitted to an existing NC burning machine and the original NC controller is replaced. (3) NEW CONTROLLER, OPTICAL TRACER BURNING MACHINE; currently work is being performed on a retrofit package that will allow an Optical Tracing burning machine to be upgraded to an NC machine. The end user will have the option to switch back and forth between Optical and NC as desired. When the system is switched to NC it becomes a DNC network node with all of the capabilities of the standard NC controller. (4) NEW CNC BURNING MACHINE; in order to accommodate end users-who have invested in NC burning machines and do not wish to replace the controller, but do wish to attach the machine to the DNC network, an additional network

component was developed. This component is connected to the existing controller at the paper tape reader connection and functions in a “Behind the Reader” (BTR) mode. The BTR component provides all of the network communication capability thus making the attached CNC controller a functionally equivalent network node.

With these four combinations it is possible to completely incorporate any combination of burning machines in a shipyard into a DNC network without extensive across the board capital equipment replacement.

(2) DNC Central Computer Component

Having discussed the Burning Machine Controller components, which represent the ends or nodes of the network, I would now like to discuss the development of the central element of the network. Information coming from any external source destined for any other external node must be controlled by, and passed through, this control element. A major design criteria for this central element is that it be flexible enough to accommodate a wide range of diverse uses and be capable of meeting the requirements of both large and small networks.

Another major design criteria was the need to be able to not only, communicate internally with the end nodes of the DNC network, but to also have the capability of communication

to the outside world. This would allow for the connection of the network to any outside CAD service such as Spades or Autocon.

The resultant development effort produced a centralized DNC computer system built" around the general purpose Digital PDP-11 Computer family. The internal operation of the system is divided into three general categories, DNC operation, CAD operation, and CAM operation. These three categories are all under the control of a master executive operating system and each category is capable of operating independently within the computer at the same time.

The major functions of the DNC operation involve actual communication with the burning machine controllers. A central parts library is accessed by the DNC subsystem and the requested part is fetched from the library and transmitted to the requesting node in the network. The DNC subsystem is also responsible for collecting operational data coming in from the burning machine nodes, time stamping each piece, and storing the results for later use.

The CAD operation concerns itself with allowing the user to perform part edit and verify functions, or to communicate directly to an external CAD service via telephone lines. In either case the program parts being worked upon are then directly stored into the central parts library.

The CAM operation concerns itself with Management Information

Systems (MIS) work. Programs operating within this category can have access to data stored within the centralized storage system and produce customized management reports.

All of these subsystems, DNC, CAD, CAM, have been designed to be open-ended. This means that they can readily accommodate additional features or applications as they become available.

IV Applying the Network to INTEGRATED MANUFACTURING

Once the network is installed, the end user can then begin to integrate his manufacturing process. The reason I say the word begin is because I believe the process is an evolutionary one.

The immediate benefits the user will experience are:

(1) Complete elimination of physical paper tape

(2) Establishment of a common Parts Library that is easily accessible by both individuals programming the parts, and by individuals burning the parts

(3) Automatic burning machine operations reports derived from the information gathered from actual operation

The network is capable of going much further than that, however. The open-ended design of the DNC, CAD, and CAM subsystems within the central DNC computer allow for additional features to be added in the future. Thus each individual network can grow as much as the user desires. For example, the CAM subsystem could incorporate an Inventory Control Application Program, either based upon an external inventory control system, or one operating entirely within the network. This inventory

control program could interface with the actual burning information derived from the DNC subsystem. Another application program could be to set up a burning schedule that would automatically inform the burning machine operators which plate is next, etc. This application could also interface with the inventory control application. The CAD subsystem could accommodate a nesting application, and so on--.

The main point is that once the-network is established, the tools are there to use. I believe each individual installation with a network of this kind will evolve differently, each customizing to meet their individual needs.

The limit of the network's usefulness is a function of the users desires, motivations, and commitment of energy to make the network perform.